Stability analysis of a steady free surface flow calculation using the dynamic boundary condition for the surface update

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ABSTRACT

A steady free surface flow problem is often encountered in marine applications, for example to predict ship wave-resistance or to study ship-to-shore interaction in straight narrow channels. These cases can be simulated using either surface fitting or surface capturing methods. The former make use of a deforming mesh which follows the free surface, and usually neglect the influence of the air. In the latter, the free surface does not coincide with cell boundaries, but is often reconstructed from a phase marker. Fitting methods have the potential of being cheaper and more accurate than capturing methods in some cases [1].

Most fitting methods use the kinematic boundary condition to update the free surface in an iterative procedure, see for example Tzabiras [2]. Such a transient approach typically converges slowly for the cases mentioned above. Raven and van Brummelen [3] proposed to combine the dynamic and kinematic boundary conditions, giving rise to an efficient steady iterative method. However, this method requires a dedicated RANS solver so that it cannot (easily) be implemented in existing (non-)commercial software.

The goal of our research is to develop a method which works with CFD packages that support moving meshes. The feasibility of using the dynamic boundary condition as surface update method is investigated with a stability analysis, initially for non-viscous flow in a straight channel. This has the advantage that the solution and therefore the error are precisely known. Implementation of fluid-structure interaction (FSI) methods to speed up convergence is also considered.

REFERENCES

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